



# Hematophagous biting midges (Diptera: Ceratopogonidae) from Tefé municipality, Amazonas state, Brazil

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**Abstract:** Some species of biting midges are vectors of pathogens that cause disease in vertebrates, including humans. The aim of this study was to survey the biting midge fauna in Tefé, Amazonas, Brazil. *Culicoides* were collected using HP light traps during January, February, and April 2013. Midges collected included one species from the genus *Lectoconops* that bites humans. A total of 248 *Culicoides* individuals were collected, representing 19 species from two subgenera (*Haematomyidium* and *Hoffmania*) and four informal species groups (*carpenteri*, *leoni*, *fluvialis*, and *reticulatus*). Twelve individuals of *L. brasiliensis* were also collected, and this is the first record of *L. brasiliensis* in Amazonas. Three species of *Culicoides* were also recorded for the first time in Amazonas, including *Culicoides aitkeni*, *C. glabellus* and *C. ocumarensis*. The most abundant species were *C. hylas* (81 individuals), and *C. foxi* (27). The *Culicoides* fauna in Tefé is diverse, and proven vectors such as *C. paraensis* and *C. insignis* were found.

**Key words:** biting midges, diversity, forest environment, peridomicile environment, Middle Solimões, Amazonia

## INTRODUCTION

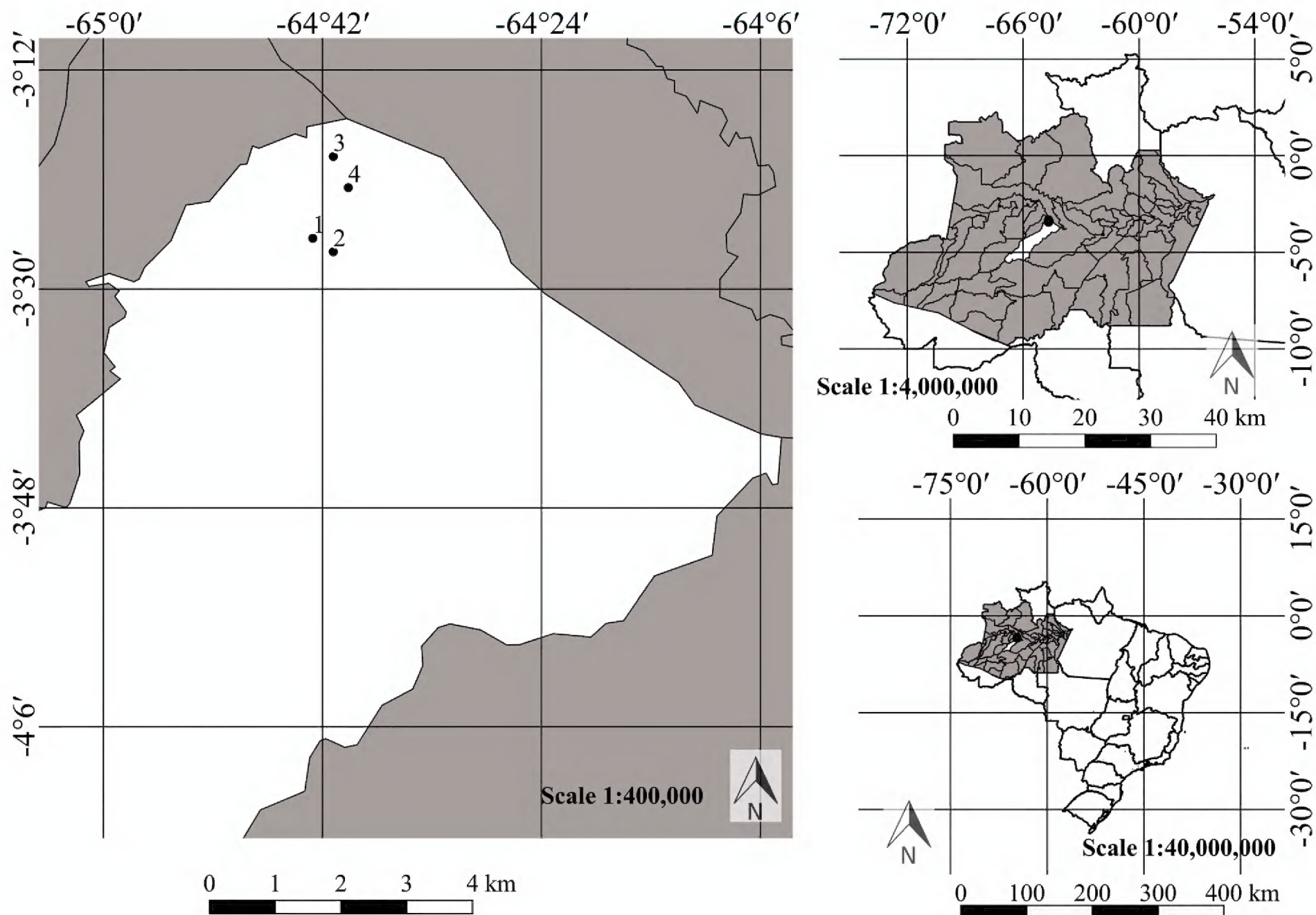
Some species of biting midges are significant vectors for several pathogens, including the viruses that cause Oropouche fever in humans and Bluetongue in domestic and wild animals (Mellor et al. 2000; Borkent and Spinelli 2007; Nunes et al. 2007). The most significant of these species is *Culicoides* Latreille, 1809. The genera *Culicoides* and *Leptoconops* Skuse, 1889 also transmit *Mansonella* Faust, 1929, which causes Mansonelliasis in humans. The bites of these insects cause skin irritation in humans and animals (Borkent 2005; Borkent and Spinelli 2007).

*Culicoides* are distributed widely throughout the world, with 273 species reported in the Neotropical region (Borkent 2012). Veras (2001) listed 82 species from the Brazilian Amazon region. Recently, 12 more species were described by Spinelli et al. (2007), Felipe-Bauer et al. (2009, 2010, 2013), Trindade and Felipe-Bauer (2011) and Santarém et al. (2014) from the states of Amazonas, Pará and Roraima. Considering that the distribution of *Culicoides reticulatus* Lutz, 1913 is now restricted to Bahia and Pernambuco states (Santarém et al. 2014), we consider 93 species known for the Brazilian Amazon.

In the Neotropical region, 12 species of the genus *Leptoconops* are distributed within four subgenera: *Brachyconops* Wirth and Atchley, 1973, *Holoconops* Kieffer, 1908, *Leptoconops*, and *Megaconops* Wirth and Atchley, 1973 (Borkent and Spinelli 2000, 2007). In Brazil, only two species have been recorded: *L. (H.) knowtoni* Clastrier and Wirth, 1978 from Santa Catarina state; and *L. (L.) brasiliensis* Lutz, 1913 from Amazonas state; however, the results of Borkent and Spinelli (2000) were corrected by Trindade and Gorayeb (2005), who restricted the distribution of *L. brasiliensis* to Pará state. Pessoa et al. (2012) have found *L. brasiliensis* in Acre state, on the triple border of Brazil, Peru, and Bolivia, and they speculated that the species is distributed widely throughout the Amazon basin.

Recent studies have shown that Mansonelliasis is endemic in the Middle Solimões basin, and that infection prevalence is high in humans that live in the riverine communities of Tefé municipality (Medeiros et al. 2014a, 2014b). These communities are situated in “várzea” environments (lowland Amazonian forest that floods in the rainy season), and “terra firme” environments (upland Amazonian forest that never floods); these two environments comprise most of the Amazonas state landscape. However, until now,





**Figure 1.** Map of study area. Location of biting midges collection areas in January, February and April 2013 in Tefé municipality, Amazonas, Brazil. Numbers correspond to locales: (1) km 03, (2) km 08, (3) Nossa Senhora do Perpétuo Socorro community and (4) Porto Vale community.

surveys of hematophagous biting midges fauna have not been conducted in this region. The aim of this study was to survey the biting midges fauna of the genera *Culicoides* and *Leptoconops* and identify differences in faunal composition between “várzea” and “terra firme” environments along the Solimões River.

## MATERIALS AND METHODS

### Study area

Tefé municipality ( $03^{\circ}21'05''$  S,  $064^{\circ}42'53''$  W) is located in the middle of Amazonas state, Brazil. It is one of ten municipalities that comprise the Middle Solimões region (Figure 1). It is 23,704.488 km<sup>2</sup> in area, and has a population of 61,453 inhabitants (IBGE 2014). The climate is classified as Af in the Köppen classification scheme: tropical rainforest with no dry season (minimum rainfall of 60 mm per month), and no cold season (monthly temperatures averaging above 18°C with annual temperatures oscillating by no more than 5°C) (INMET 2013). The main vegetation is comprised of dense ombrophylous forest lowlands (rolling lowlands that do not flood and have emerging canopy trees) and alluvial ombrophylous forests (which occur along water courses and are subject to annual white water flooding; they can have open canopies, uniform canopies, or emerging canopy trees) (Vivona et al. 2003).

Biting midges were collected in forest and peridomestic areas near small farms in both “terra firme” (upland) and “várzea” (lowland) environments. The entomological surveys were conducted in the following localities: EMADÉ road (km 03 and km 08), Nossa Senhora do Perpétuo Socorro community, and Porto Vale community (Figure 1). Collections were made using HP light traps that were set for eight consecutive nights per month (6:00–7:00 h) during January, February, and April 2013. In June 2012, Medeiros et al. (2014b) conducted an epidemiological study of Mansonelliasis in Tefé municipality; they collected some hematophagous insects in the margins of the Solimões River near “várzea” environments, and they collected some diurnal biting midges.

### Data collection

Following each capture event, biting midges were preserved in 90% alcohol and taken to Laboratório de Ecologia e Doenças Transmissíveis da Amazônia (EDTA/Fiocruz-Amazônia) in Manaus Municipality, Amazonas state. The specimens were slide-mounted in phenol-balsam in the manner described by Wirth and Marston (1968). Identification was performed using a variety of identification keys, including those of Spinelli et al. (1993, 2005), Veras (2001), Felipe-Bauer et al. (2009).



Descriptive statistical analysis was performed to identify differences between environments; data from forest and peridomicile areas was compared using BioEstat version 5.2 to apply the Mann-Whitney test with a significance level of 0.05.

## RESULTS

A total of 248 *Culicoides* individuals were collected, including 14 males (5.6%) and 234 females (94.4%), representing a total of 19 species from two subgenera (*Haematomyidium* Goeldi, 1905 and *Hoffmania* Fox, 1948) and four informal species groups (*carpenteri*, *leoni*, *fluvialis*, and *reticulatus*); some individuals were considered morphotypes ( $n = 32$ ): *Culicoides* sp. 1 of subgenus *Haematomyidium*; *C. sp. 2*, *C. sp. 3*, and *C. sp. 4* of the subgenus *Hoffmania*; and *C. sp. 5*, *C. sp. 6*, and *C. sp. 7* of an unplaced subgenus from the *reticulatus* group. Three species were reported for the first time in Amazonas state: *C. aitkeni* Wirth and Blanton, 1968, *C. glabellus* Wirth and Blanton, 1956, and *C. ocumarensis* Ortiz, 1950. The most abundant species/morphotypes were *C. hylas* Macfie, 1940 ( $n = 81$ , 32.7%), *C. foxi* Ortiz, 1950 ( $n = 27$ , 10.9%), *C. sp. 7* ( $n = 23$ , 9.3%), *C. pseudodiabolicus* Barbosa, 1946 ( $n = 22$ , 8.9%), *C. paucienfuscatus* Barbosa, 1947 ( $n = 22$ , 8.9%) and *C. insignis* Lutz, 1913 ( $n = 20$ , 8.1%) (Table 1). From the genus *Leptoconops*, 12 individuals belonging to *L. brasiliensis* were collected, but as this species was collected at a different time using a different method, it was not included in Table 1.

The “terra firme” environments exhibited high abundance and low species richness (147 individuals and 15 species) in comparison with lowland “várzea” environments (101 individuals and 17 species). The most abundant species in “terra firme” environments were *C. hylas* ( $n = 79$ , 31.8%), *C. foxi* ( $n = 21$ , 8.4%), and *C. paraignacioi* Spinelli, 1993 ( $n = 10$ , 4.0%). The species unique to this environment included: *C. aitkeni*, *C. benarrochi* Ortiz and Mirsa, 1952, *C. coutinhoi* Barretto, 1944, *C. filariferus* Hoffman, 1939, *C. glabrior* Macfie, 1940, *C. ocumarensis* and *C. paraignacioi*. The most abundant species/morphotypes in “várzea” environments were *C. sp. 7* ( $n = 23$ , 9.2%), *C. paucienfuscatus* ( $n = 22$ , 8.8%), and *C. insignis* ( $n = 20$ , 8.1%). The species unique to this environment include *C. belemensis* Wirth and Blanton, 1973, *C. debilipalpis* Lutz, 1913, *C. insignis*, *C. leopoldoi* Ortiz, 1951, *C. paraensis* (Goeldi, 1905) and *C. paucienfuscatus* Barbosa, 1947. Forests exhibited higher abundance than peridomicile areas (Mann-Whitney  $U = 36$   $P = 0.03$ ).

## DISCUSSION

The 19 species of *Culicoides* found in Tefé (and the seven morphotypes) represent approximately 25% of the *Culicoides* fauna in the Brazilian Amazon. The diversity of *Culicoides* fauna in the Brazilian Amazon

has likely been underestimated because too few *Culicoides* studies in this region. The seven morphotypes documented here may represent new species. In a recent revision of the *reticulatus* species group, five new species were described in the Brazilian Amazon (Santarém et al. 2014), which demonstrates that our knowledge of *Culicoides* fauna remains incomplete. The low density of males in the catch is most likely the result of copulation behavior (Castellon et al. 1990) that usually occurs near oviposition sites and food sources.

*Culicoides aitkeni*, *C. glabellus* and *C. ocumarensis* were recorded for the first time in Amazonas state. *Culicoides aitkeni* is prevalent in Trinidad and Tobago and Brazil, where it occurs in Pará state (Felippe-Bauer et al. 2009). *Culicoides glabellus* is prevalent between Honduras and Ecuador, in Trinidad and Tobago, and in Brazil, where it occurs in Bahia state (Borkent and Spinelli 2007). *Culicoides ocumarensis* is prevalent throughout the Americas, from the United States to Argentina, and it has been recently isolated in Peru and Brazil, where it occurs in the states of Pará and Rondônia (Borkent and Spinelli 2007; Felippe-Bauer et al. 2008).

Lutz (1913) described *L. brasiliensis* (as *Tersesthes brasiliensis*) from the lower Tocantins River, but he did not identify the state, which was Pará. Borkent and Spinelli (2000) used the type locality to establish the presence of *L. brasiliensis* in Amazonas state, but Trindade and Gorayeb (2005) corrected this result by restricting *L. brasiliensis* to Pará state. Pessoa et al. (2012) recorded *L. brasiliensis* in Acre state in the Southeastern Amazon. This means that our collections in Tefé municipality are the first confirmed finds of *L. brasiliensis* in Amazonas state.

*Culicoides* species diversity was higher in “várzea” environments than it was in “terra firme” environments. Studies in Amazonas state have been conducted primarily in “terra firme” environments (Castellón and Ferreira 1991; Veras and Castellón 1998; Veras 2001; Silva and Bermúdez 2009). In “várzea” environments, *Culicoides* fauna remains largely unknown. The fauna found in forests was richer and more abundant than fauna found in peridomicile areas, and peridomiciles in “terra firme” environments exhibited significantly less richness and abundance than all other environments.

This study identified *C. hylas* as the most abundant species in Tefé municipality, and this species has also been identified as the most abundant in other regions of Amazonas state, including Manaus and São Gabriel da Cachoeira (Veras and Castellón 1998; Silva and Bermúdez 2009), and *C. hylas* is not currently considered a species of medical importance. Of the species collected in this study, nine have anthropophilic habits: *C. benarrochi*, *C. debilipalpis*, *C. foxi*, *C. glabellus*, *C. insignis*, *C. leopoldoi*, *C. paraensis*, *C. paraignacioi*, *C. pseudodiabolicus* (Aitken et al. 1975; Bermúdez 1986; Castellón and Ferreira 1991;



**Table 1.** *Culicoides* collected with HP light traps in “várzea” and “terra firme” environments in Tefé municipality, Amazonas state, Brazil during the months of January, February, and April 2013.

Subgenus /Species Group	Species	"Várzea"				"Terra Firme"				Total	%		
		F		P		F		P					
		♂	♀	♂	♀	♂	♀	♂	♀				
Haematomyidum	<i>Culicoides debilipalpis</i> Lutz, 1913	1	0	0	0	0	0	0	0	1	0	1	0.4
	<i>Culicoides glabrior</i> Macfie, 1940	0	0	0	0	3	5	0	0	0	8	8	3.2
<i>Haematomyidum/paraensis</i> Group	<i>Culicoides paraensis</i> (Goeldi, 1945)	1	1	0	0	0	0	0	0	2	0	2	0.8
	<i>Culicoides</i> sp. 1	0	0	0	0	0	0	0	0	1	0	1	0.4
<i>Hoffmania/gutatus</i> Group	<i>Culicoides coutinhoi</i> Barretto, 1944	0	0	0	0	0	2	0	0	0	2	2	0.8
	<i>Culicoides diabolicus</i> Hoffman, 1925	0	0	0	1	0	2	0	0	1	2	3	1.2
	<i>Culicoides filiferus</i> Hoffman, 1939	0	0	0	0	0	2	0	0	0	2	2	0.8
	<i>Culicoides foxi</i> Ortiz, 1950	0	2	0	4	0	20	0	1	6	21	27	10.9
	<i>Culicoides insignis</i> Lutz, 1913	0	0	0	20	0	0	0	0	20	0	20	8.1
	<i>Culicoides ocumarensis</i> Ortiz, 1950*	0	0	0	0	0	6	0	0	0	6	6	2.4
	<i>Culicoides paraignacioi</i> Spinelli, 1993	0	0	0	0	0	10	0	0	0	10	10	4.0
	<i>Culicoides pseudodiabolicus</i> Fox, 1946	0	8	0	5	0	9	0	0	13	9	22	8.9
	<i>Culicoides</i> sp. 2	0	1	0	0	0	0	0	0	1	0	1	0.4
	<i>Culicoides</i> sp. 3	0	0	0	0	0	3	0	0	0	3	3	1.2
	<i>Culicoides</i> sp. 4	0	0	0	1	0	0	0	0	1	0	1	0.4
<i>Hoffmania/hylas</i> Group	<i>Culicoides aitkeni</i> Wirth and Blanton, 1968*	0	0	0	0	0	1	0	0	0	1	1	0.4
	<i>Culicoides hylas</i> Macfie, 1940	0	2	0	0	8	71	0	0	2	79	81	32.7
	<i>Culicoides verecundus</i> Macfie, 1949	0	1	0	1	0	1	0	0	2	1	3	1.2
Unplaced/ <i>carpenteri</i> Group	<i>Culicoides belemensis</i> Wirth and Blanton, 1973	0	1	0	1	0	0	0	0	2	0	2	0.8
Unplaced/ <i>fluvialis</i> Group	<i>Culicoides leopoldoi</i> Ortiz, 1951	0	2	0	0	0	0	0	0	2	0	2	0.8
Unplaced/ <i>leoni</i> Group	<i>Culicoides benarrochi</i> Ortiz and Mirsa, 1952	0	0	0	0	0	1	0	0	0	1	1	0.4
	<i>Culicoides glabellus</i> Wirth and Blanton, 1956*	0	1	0	0	0	1	0	0	1	1	2	0.8
Unplaced/ <i>reticulatus</i> Group	<i>Culicoides paucienfuscatus</i> Barbosa, 1947	0	0	1	21	0	0	0	0	22	0	22	8.9
	<i>Culicoides</i> sp. 5	0	0	0	1	0	0	0	0	1	0	1	0.4
	<i>Culicoides</i> sp. 6	0	0	0	1	0	0	0	0	1	0	1	0.4
	<i>Culicoides</i> sp. 7	0	1	0	22	0	0	0	0	23	0	23	9.3
Total		2	20	1	78	11	134	0	2	101	147	248	100
%		0.8	8.1	0.4	31.5	4.4	54.0	0.0	0.8	40.7	59.3	100	

F: Forest, P: Peridomicile.\*New records to Amazonas state.



Trindade and Gorayeb 2005, 2010; Costa et al. 2013). In the areas surveyed, *C. paraensis* and *C. insignis* were found in relatively low numbers; however, these species are considered to be of medical and veterinary importance, and it is possible for some species to be underrepresented in entomological studies. Low frequency can be the result of several factors including collection method, type of bait, environmental characteristics, and the presence of animals (Costa et al. 2013). Low frequency may also be related to diverse activity patterns which could cause diurnal and nocturnal species to be disproportionately represented (Koch and Axtel 1979; Hoch et al. 1990).

*Culicoides paraensis* has been proven to be a vector of Oropouche virus (Pinheiro et al. 1981; Borkent and Spinelli 2007). It is found throughout the Americas, from Argentina to the United States (Felippe-Bauer et al. 2003), and it is the most studied species of the New World *Culicoides*. High incidences of ORO virus have been reported in urban and wild areas in several states of the Brazilian Amazon. It is estimated that half a million cases have occurred in Brazil over the last 30 years (Borkent 2005; Teixeira Nunes et al. 2005; Azevedo et al. 2007). Outbreaks of Oropouche fever have also occurred in Trinidad and Tobago, Panamá, Peru, and Ecuador (Baisley et al. 1998; Borkent 2005; Azevedo et al. 2007; PAHO 2010).

*Culicoides paraensis* has been incriminated as a secondary vector of *Mansonella ozzardi* (Manson, 1897) (Romaña and Wygodzinsky 1950; Shelley and Coscarón 2001), and it has been frequently found in the Upper Rio Negro region of Amazonas state (Silva and Bermúdez 2009). *Mansonella ozzardi* is widely distributed throughout Amazonas state; instances have been recorded since the late 1940s (Deane 1949), and high levels of transmission and infection prevalence have been observed in the Middle Solimões basin (Martins et al. 2010; Medeiros et al. 2014a, 2014b).

*Culicoides insignis* is a proven vector of bluetongue virus (BTV) and is found throughout the Americas, from the United States to Argentina. In Brazil, BTV has spread through the southern parts of the North Region, with positive serological cases recorded in several states including Amazonas (Scolari et al. 2011; Dorneles et al. 2012). In the Amazon Basin, the occurrence of *L. brasiliensis* is probably widespread, and beside the effects of its bites, the medical importance in Brazil is unknown; however, the fact that *L. brasiliensis* has been collected in an area of endemic mansonelliasis, means that it should be studied further.

## Conclusion

The hematophagous biting midges fauna in Tefé municipality was found to be diverse. Abundance was highest in upland environments, while species diversity was slightly higher in lowland environments.

The fauna surveyed included species incriminated as vectors of Oropouche virus, *Mansonella* and bluetongue virus, which indicates that this region could be at risk. Further studies using different capture methods will be needed to improve our understanding of *Culicoides* and *Leptoconops* fauna in the Middle Solimões basin.

## ACKNOWLEDGEMENTS

The authors would like to acknowledge: the financial support of FAPEAM, Grant Number 007/2009; the inhabitants of the Nossa Senhora do Perpétuo Socorro and Porto Vale communities; FAPEAM PAIC from whom JAF had Grant Number 062.01577/2014; and to Maria Luiza Felipe-Bauer for her invaluable corrections to, and suggestions for, the first draft of the manuscript.

## LITERATURE CITED

- Aitken, T.H.G., W.W. Wirth, R.W. Williams, J.B. Davies and E.S. Tikasingh. 1975. A review of the bloodsucking midges of Trinidad and Tobago. *Journal of Entomology Series B, Taxonomy* 44: 101–144. doi: [10.1111/j.1365-3113.1975.tb00007.x](https://doi.org/10.1111/j.1365-3113.1975.tb00007.x)
- Azevedo, R.S.S., M.R.T. Nunes, J.O. Chiang, G. Bensabath, H.B. Vasconcelos, A.Y.N. Pinto, L.C. Martins, H.A.D.O. Monteiro, S.G. Rodrigues and P.F.D.C. Vasconcelos. 2007. Reemergence of Oropouche fever, Northern Brazil. *Emerging Infectious Diseases* 13: 912–915. doi: [10.3201/eid1306.061114](https://doi.org/10.3201/eid1306.061114)
- Baisley, K.J., D.M. Watts, L.E. Munstermann and W.L. Mark. 1998. Epidemiologic of endemic Oropouche virus transmission in upper Amazonian Peru. *The American Society of Tropical Medicine and Hygiene* 59: 710–716.
- Bermúdez, E.G.C. 1986. *Culicoides* (Diptera: Ceratopogonidae) antropófilos na Reserva Florestal Ducke: abundância sazonal durante o dia [Ph.D. thesis]. Manaus: Instituto Nacional de Pesquisas da Amazônia. 186 pp.
- Borkent, A. and G.R. Spinelli. 2000. Catalog of the New World biting midges south of the United States of America (Diptera: Ceratopogonidae). *Contributions to Entomology International* 4: 1–108.
- Borkent, A. 2005. The biting midges, Ceratopogonidae (Diptera); pp. 113–126, in: W. C. Marquardt. *Biology of disease vectors*. San Diego: Elsevier Academic.
- Borkent, A. and G.R. Spinelli. 2007. Neotropical Ceratopogonidae (Diptera: Insecta). Sofia-Moscow: Pensoft Publishers. 198 pp.
- Borkent, A. 2012. World species of Biting Midges (Diptera: Ceratopogonidae). *Bulletin of the American Museum of Natural History*. Accessed at <http://www.inhs.illinois.edu/files/8413/4219/9566/CeratopogonidaeCatalog.pdf>. 20 January 2014.
- Castellón, E.G., R.L.M. Ferreira and M.N.T. Silva. 1990. *Culicoides* (Diptera: Ceratopogonidae) na Amazônia brasileira. I. Coletas na usina hidrelétrica (UHE) de Balbina, usina hidrelétrica (UHE) Cachoeira Porteira e Cachoeira dos Espelhos (Rio Xingú). *Acta Amazonica* 20: 77–81.
- Castellón, E.G. and R.L.M. Ferreira. 1991. *Culicoides* Latreille (Diptera: Ceratopogonidae) da Amazônia. III. Resultados de coletas noturnas, na Reserva Florestal Ducke, Estado do Amazonas, Brasil. *Boletim do Museu Paraense Emílio Goeldi* 7: 117–123.
- Costa, J.C., E.S. Lorosa, J.L.P. Moraes and J.M.M. Rebelo. 2013. Espécies de *Culicoides* (Diptera: Ceratopogonidae) e hospedeiros potenciais em área de ecoturismo do Parque Nacional dos Lençóis Maranhenses, Brasil. *Revista Pan-Amazônica de Saúde* 4: 11–18. doi: [10.5123/S2176-62232013000300002](https://doi.org/10.5123/S2176-62232013000300002)
- Deane, M.P. 1949. Sobre a incidência de filárias humanas em Manaus,



- estado do Amazonas. Revista do Serviço Especial em Saúde Pública 2: 849–858.
- Dorneles, E.M.S., F.C. Morcatti, A.S. Guimaraes, Z.I.P. Lobato, A.P. Lage, V.S.P. Gonçalves, A.M.G. Gouveia and M.B. Heinemann. 2012. Prevalence of bluetongue virus antibodies in sheep from Distrito Federal, Brazil. Semina: Ciências Agrárias 33: 1521–1524. doi: [10.5433/1679-0359.2012v33n4p1521](https://doi.org/10.5433/1679-0359.2012v33n4p1521)
- Felippe-Bauer, M.L., A.G. Cáceres, C.S. Silva, W. Valderrama-Bazan and A. Gonzalez-Perez. 2003. Two new *Culicoides* of the *paraensis* species group (Diptera: Ceratopogonidae) from the Amazonian region of Peru. Memórias do Instituto Oswaldo Cruz 98: 1051–1058. doi: [10.1590/S0074-02762003000800014](https://doi.org/10.1590/S0074-02762003000800014)
- Felippe-Bauer, M.L., A. Cáceres, C.S. Silva, W. Valderrama-Bazan, A. Gonzales-Perez and J.M. Costa. 2008. New records of *Culicoides* Latreille (Diptera: Ceratopogonidae) from Peruvian Amazonian region. Biota Neotropica 8: 33–38. doi: [10.1590/S1676-06032008000200002](https://doi.org/10.1590/S1676-06032008000200002)
- Felippe-Bauer, M.L., C.P. Damasceno, V. PY-Daniel and G.R. Spinelli. 2009. *Culicoides baniwa* sp. nov. from the Brazilian Amazon region with a synopsis of the *Hylas* species group (Diptera: Ceratopogonidae). Memórias do Instituto Oswaldo Cruz 104: 851–857. doi: [10.1590/S0074-02762009000600005](https://doi.org/10.1590/S0074-02762009000600005)
- Felippe-Bauer, M.L., C.P. Damasceno, R.L. Trindade and V. Py-Daniel. 2010. A new *Culicoides* (Diptera: Ceratopogonidae) of the *reticulatus* species group from Brazilian Amazon region. Memórias do Instituto Oswaldo Cruz 105: 863–865. doi: [10.1590/S0074-02762010000700004](https://doi.org/10.1590/S0074-02762010000700004)
- Felippe-Bauer, M.L., T.N. Silva and R.L. Trindade. 2013. New *Culicoides* Latreille of the subgenus *Mataemyia* Vargas from Pará, Brazil (Diptera: Ceratopogonidae). Memórias do Instituto Oswaldo Cruz 108: 54–58. doi: [10.1590/S0074-02762013000100009](https://doi.org/10.1590/S0074-02762013000100009)
- Hoch, A.L., D.R. Roberts and F.P. Pinheiro. 1990. Host-seeking behavior and seasonal abundance of *Culicoides paraensis* (Diptera: Ceratopogonidae) in Brazil. Journal of the American Mosquito Control Association 6: 110–114.
- Instituto Brasileiro de Geografia e Estatística (IBGE). 2014. Cidades IBGE. Accessed at <http://cod.ibge.gov.br/232TR>, 11 November 2014.
- Instituto Nacional de Meteorologia (INMET). 2013. Banco de dados meteorológicos para ensino e pesquisa. Accessed at <http://www.inmet.gov.br/portal/index.php?r=bdmep/bdmep>, 10 June 2013.
- Koch, H.G. and R.C. Axtel. 1979. Attraction of *Culicoides furens* and *C. hollensis* (Diptera: Ceratopogonidae) to animal hosts in a salt marsh habitat. Journal of Medical Entomology 15: 494–499.
- Lutz, A. 1913. Contribuição para o estudo das Ceratopogoninas hematofagas do Brasil. Memórias do Instituto Oswaldo Cruz 5: 45–73. doi: [10.1590/S0074-02761913000100005](https://doi.org/10.1590/S0074-02761913000100005)
- Martins, M., F.A.C. Pessoa, M.B. Medeiros, E.V. Andrade and J.F. Medeiros. 2010. *Mansonella ozzardi* in Amazonas, Brazil: prevalence and distribution in the municipality of Coari, in the middle Solimões River. Memórias do Instituto Oswaldo Cruz 105: 246–253. doi: [10.1590/S0074-02762010000300002](https://doi.org/10.1590/S0074-02762010000300002)
- Medeiros, J.F., C.A. Costa, A.M. Lima and F.A.C. Pessoa. 2014a. *Mansonella ozzardi* (Nematoda: Onchocercidae) in the riverine population of the Tefé River, state of Amazonia, Brazil. Revista da Sociedade Brasileira de Medicina Tropical 47: 113–115. doi: [10.1590/0037-8682-0031-2012](https://doi.org/10.1590/0037-8682-0031-2012)
- Medeiros, J.F., M.S. Rodrigues, T.H. Katsuragawa, C.A. Costa and F.A.C. Pessoa. 2014b. *Mansonella ozzardi* in the municipality of Tefé, Amazonas, Brazil, 60 years after the first report: an epidemiologic study. Memórias do Instituto Oswaldo Cruz 109: 480–483. doi: [10.1590/0074-0276130512](https://doi.org/10.1590/0074-0276130512)
- Mellor, P.S., J. Boorman and M. Baylis. 2000. *Culicoides* biting midges: their role as arbovirus vectors. Annual Review of Entomology 45: 307–340. doi: [10.1146/annurev.ento.45.1.307](https://doi.org/10.1146/annurev.ento.45.1.307)
- Nunes, M.R.T., H.B. Vasconcelos, D.B.A. Medeiros, G.S. Rodrigues, R.S.S. Azevedo, J.O. Chiang, L.C. Martins and P.F.C. Vasconcelos. 2007. A Febre do Oropouche: uma revisão dos aspectos epidemiológicos e moleculares na Amazônia Brasileira. Cadernos de Saúde Coletiva 15: 303–318.
- PAHO. 2010. Epidemiological alert: outbreak of Oropouche Fever. Pan American Health Organization Bulletin 1: 1–2.
- Pessoa, F.A.C., E.G. Castellón-Bermudez, J.F. Medeiros and L.M.A. Camargo. 2012. First occurrence of the human biting midge *Leptoconops brasiliensis* (Lutz) (Diptera: Ceratopogonidae) in the triple border of Brazil, Peru, and Bolivia. Revista da Sociedade Brasileira de Medicina Tropical 45: 138–139. doi: [10.1590/S0037-86822012000100030](https://doi.org/10.1590/S0037-86822012000100030)
- Pinheiro, F.P., A.P.A. Travassos da Rosa, J.F.S. Travassos da Rosa, R. Ishak, R.B. Freitas, M.L.C. Gomes, J.W. Leduc and O.F.P. Oliva. 1981. Oropouche virus. I. A review of clinical, epidemiological, and ecological findings. American Journal of Tropical Medicine and Hygiene 30: 149–160.
- Romaña, C. and P. Wygodzinsky. 1950. Acerca de la transmission de *Mansonella ozzardi* (Manson) (Filaria tucumana Biglieri y Araoz). Anales del Instituto de Medicina Regional 3: 29–34.
- Santarém, M.C.A., R.L. Trindade, T. N. Silva, E.G. Castellón, C.A.M. Patiu and M.L. Felipe-Bauer. 2014. New Neotropical *Culicoides* and redescription of *Culicoides reticulatus* Lutz (Diptera: Ceratopogonidae). Zootaxa 3795: 255–274. doi: [10.11646/zootaxa.3795.3.2](https://doi.org/10.11646/zootaxa.3795.3.2)
- Scolari, A.P.R., B.R. Ayub, C.S. Sotomaior and R.D. Ollhoff. 2011. O vírus da língua azul em ruminantes domésticos: situação de alerta no Brasil – Revisão. Revista Acadêmica Ciências Agrárias e Ambientais 9: 407–413.
- Shelley, A.J. and S. Coscarón. 2001. Simuliid blackflies (Diptera: Simuliidae) and ceratopogonid midges (Diptera: Ceratopogonidae) as vectors of *Mansonella ozzardi* (Nematoda: Onchocercidae) in northern Argentina. Memórias do Instituto Oswaldo Cruz 96: 451–458. doi: [10.1590/S0074-02762001000400003](https://doi.org/10.1590/S0074-02762001000400003)
- Silva, L.G. and E.G.C. Bermúdez. 2009. Diversidade e abundância de *Culicoides* (Diptera: Ceratopogonidae) no Alto Rio Negro. Livros de Resumos da 61a. Reunão Anual da SBPC, 1. Accessed at <http://www.sbpnet.org.br/livro/61ra/resumos/resumos/6082.htm>, 20 January 2015.
- Spinelli, G.R., E.C. Greiner and W.W. Wirth. 1993. The neotropical bloodsucking midges of the *Culicoides guttatus* group of the subgenus *Hoffmania* (Diptera: Ceratopogonidae). Contributions of the American Entomological Institute 27: 1–91.
- Spinelli, G.R., M.M. Ronderos, F. Díaz and P.I. Marino. 2005. The bloodsucking biting midges of Argentina (Diptera: Ceratopogonidae). Memórias do Instituto Oswaldo Cruz 100: 137–150. doi: [10.1590/S0074-02762005000200006](https://doi.org/10.1590/S0074-02762005000200006)
- Spinelli, G.R., M.M. Ronderos, P.I. Marino, D.S. Carrasco and R.L. Menezes Ferreira. 2007. Description of *Culicoides* (*Mataemyia*) *felippebaueri* sp. n., *Forcipomyia musae* immatures, and occurrence of *F. genualis*, breeding in banana stems in Brazilian Amazonia (Diptera: Ceratopogonidae). Memórias do Instituto Oswaldo Cruz 102: 659–669. doi: [10.1590/S0074-02762007005000083](https://doi.org/10.1590/S0074-02762007005000083)
- Teixeira Nunes, M.R., L. Carício Martins, S. Guerreiro Rodrigues, J.O. Chiang, R.S.S. Azevedo, A.P.A. Travassos da Rosa and P.F.C. Vasconcelos. 2005. Oropouche virus isolation, Southeast Brazil. Emerging Infectious Diseases 11: 1610–1613. doi: [10.3201/eid1110.050464](https://doi.org/10.3201/eid1110.050464)
- Trindade, R.L. and I.S. Gorayeb. 2005. Maruins (Ceratopogonidae: Diptera) do estuário do rio Pará e do litoral do estado do Pará, Brasil. Entomologia y Vectores 12: 61–74. doi: [10.1590/S0328-03812005000100005](https://doi.org/10.1590/S0328-03812005000100005)
- Trindade, R.L. and I.S. Gorayeb. 2010. Maruins (Diptera: Ceratopogonidae: Culicoides), após a estação chuvosa, na Reserva de Desenvolvimento Sustentável Itatupã-Baquiá, Gurupá, Pará, Brasil. Revista Pan-Amazônica de Saúde 1: 121–130. doi: [10.5123/](https://doi.org/10.5123/)



- S2176-62232010000200015
- Trindade, R.L. and M.L. Felipe-Bauer. 2011. Two new biting midges from Pará, Brazil (Diptera: Ceratopogonidae). *Memórias do Instituto Oswaldo Cruz* 106: 61–64. doi: [10.1590/S0074-02762011000100010](https://doi.org/10.1590/S0074-02762011000100010)
- Veras, R.S. 2001. *Culicoides* (Diptera: Ceratopogonidae) na Amazônia Brasileira, distribuição Biogeográfica e chave de identificação [Ph.D. thesis]. Manaus: Instituto Nacional de Pesquisas da Amazônia. 213 pp.
- Veras, R.S. and E.G. Castellón. 1998. *Culicoides latreille* (Diptera, Ceratopogonidae) in Brazilian Amazon. V: efficiency of traps and baits and vertical stratification in the forest Reserve Adolpho Ducke. *Revista Brasileira de Zoologia* 15: 145–152. doi: [10.1590/S0101-81751998000100012](https://doi.org/10.1590/S0101-81751998000100012)
- Vivona, S.N., H.R.V. Sesubiani, L.P. Bruscato and D.O. Adileu. 2003. Relatório de Impactos Ambientais (RIMA), Usina Termelétrica de Tefé, Amazonas. Relatórios de Impactos ao Meio Ambiente. 92 pp.
- Wirth, W.W. and N. Marston. 1968. Method for mounting small insects on microscope slides in Canada balsam. *Annals of the Entomological Society of America* 61: 783–784.
- Authors' contribution statement:** ESF participated in sample design, identified the insects, and co-wrote the text; AMPJ participated in sample design, collected insects, and co-wrote the text; JFA mounted the insects and co-wrote the article; FACP participated in sample design, collected insects, and co-wrote the text; JFM participated in sample design, collected insects, performed the data analysis, and co-wrote the text.
- Received:** 26 March 2015
- Accepted:** 2 June 2015
- Academic editor:** Jonas da Silva Döge